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ABSTRACT

Small-group cooperative learning was integrated into a physics class to alter the traditional lecture/laboratory format of the course and to provide support for students' feelings of helplessness and isolation in studying physics. At weekly meetings, groups of 4-6 students met to solve physics homework problems assigned during the traditional lecture of the course. Weekly journals kept by individuals in the cooperative learning groups were used to acquire information about the attitudes and general functioning of each of the groups. This paper describes the affective outcomes associated with incorporating small-group cooperative learning in the second semester of a pilot phase of a college physics course. This course was designed for non-science majors, most of whom are female and taking the course as one of the requirements for elementary teacher certification. Included are the theoretical framework, design and procedure, results, discussion, conclusions, and implications for further study. (KR)

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MOTIVATIONAL PATTERNS IN NON-SCIENCE MAJORS RELATED TO LEARNING PHYSICS

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Theoretical Framework

In discussing the subject matter preparation of teachers, Ball and McDiarmid (l990) remind their readers that both common sense and philosophical arguments reflect the conviction that the subject matter knowledge a teacher possesses will influence the teacher's efforts to help students learn the subject matter. Ball and McDiarmid consider the central question for research on teachers' subject matter preparation to be how teachers and prospective teachers can increase their knowledge of the subject they teach. Shulman (1986) addresses this same question when he argues that investigators ignored one central aspect of classroom life in the simplification of the complexities of classroom teaching, that of the subject matter. Shulman and his colleagues refer to the absence of focus on subject matter within research paradigms for the study of teaching as the "missing paradigm" problem. Therefore as a domain of inquiry in teacher education, research on teachers' learning of subject matter is relatively new and therefore the literature is scant (Ball and McDiarmid, 1990).

Wilson, Shulman, and Richert (1987), conducting research into teachers' subject matter knowledge and the role it plays in teaching, believe that the transformation of subject matter knowledge is at the heart of teaching in public schools. Grossman, Wilson, and Shulman (1989) further believe that we have come to realize the centrality of subject matter knowledge in teaching. They therefore contend that this realization demands that "teacher educators, including faculty in both arts and sciences departments and colleges of education must encourage the reunion of pedagogy and content, not only in the theoretical world of research journals but also in the actual practice of teacher education" (p. 32).

The theoretical framework of these researchers served as the basis for reuniting pedagogy and content in the design and implementation of a physics course for non-science majors, most of whom are female and taking the course as one of the requirements for elementary teacher certification. The course, Physics 350, Concepts of Physics, was designed and pilot tested by professors from the departments of Physics and Educational Curriculum and Instruction at our university. The results of offering the course for two semesters have provided valuable information about restructuring the course to better meet the needs of this particular group of learners.

Uniting Pedagogy and Content

Physics 350 was taught as a traditional lecture/laboratory course by a physics professor the first semester that it was offered. An education professor observed several of the physics classes and interviewed groups of students three times during the first semester regarding their overall satisfaction with the course. Results of these interviews and of final course evaluations revealed that students were dissatisfied with the course and that these feelings were impinging upon student performance. Students appeared immobilized in their study. In the interviews, the students focused on their poor grades and appeared unable to offer suggestions as to how they might help themselves improve their grades. Negative attitudes towards physics and feelings of isolation and "helplessness" in "doing physics" were pervasive among students interviewed, even those of high ability with more than adequate mathematics backgrounds. The interviews and course evaluations led both professors to examine the affective needs of this particular group of learners in the hopes that improved attitudes towards learning physics and towards themselves as able learners would facilitate learning, thereby improving their success and satisfaction with the course.

The findings of the first semester are corroborated by research associated with the effects of students' attitudes on successful mathematics and science learning. A number of variables internal to the learner, such as low task persistence, fear of failure and low self concept previously have been found to affect female college students' performance in mathematics (Kloosterman, 1990) and in college science (Schumm & Kahle, 1986). Additionally, external variables including the traditional lecture/laboratory setting and competitive grading system also appear to exacerbate students' negative feelings towards difficult courses and themselves as competent learners (Davidson, 1990). Davidson is one of many who have found cooperative learning to effectively improve students' attitudes towards learning difficult subjects and towards themselves as able learners as well as effectively improving student performance (Johnson & Johnson, 1975). Davidson reports that working in cooperative groups in mathematics has many advantages for secondary and college-level students, including the production of high levels of interest in learning activities while achieving at least as much information and skill as in the more traditional approaches. Other cooperative learning studies with younger learners suggest that mixed-ability small-group instruction results in positive effects on affective outcomes such as self-esteem, academic self-confidence, and liking for the class (Good & Brophy, 1987).

Small-group cooperative learning was integrated into the Spring semester of Physics 350 to alter the traditional lecture/laboratory format of the course and to provide support for students' feelings of helplessness and isolation in studying physics. Students were required to meet once a week in cooperative learning groups, monitored and facilitated by graduate students in science education. At the weekly meetings, groups of 4-6 students met to solve physics homework problems assigned during the traditional lecture of the course. Each group turned in a group solution and was awarded a grade for the completion of the solution. Weekly journals kept by individuals in the cooperative learning groups were used to acquire information about the attitudes and general functioning of each of the groups. This paper describes the affective outcomes associated with incorporating small-group cooperative learning in the second semester of the pilot phase of Physics 350.

Design and Procedure

Students were strongly encouraged to attend cooperative learning group meetings and keep a journal of the group's meetings. Students were grouped according to their preferred meeting times. A few students indicated that they could not meet at all because of scheduling conflicts. Some students chose to receive an hour of independent study credit for their work in cooperative learning groups, and we suspect that several of those students informally assumed more responsibility for the successful recordkeeping of four of the groups. Of the six groups that were organized, five groups met regularly and one disbanded. Of the five groups that met regularly, one group lost its journal and did not turn it in. Of 37 students enrolled in the class, we received cooperative learning records for 26 students, distributed in four groups. Separate journals were also kept by graduate student mentors of these groups, but they were not used in the analysis of student records that follows.

Each group was given a hard-bound laboratory record book with written instructions for keeping a cooperative learning journal. Instructions included a suggested list of entries for each meeting, including date, time and place; secretary; members present, group goals set on that day, long range, short range, and individual person's goals; previous group goals no longer necessary; task assignments, with names of people and tasks, to include reading the book and finding pertinent information about lecture topics, seeing a tutor or professor, getting information on one's own to share with the group; a description of what happened at the meeting; and perceptions of how the group functioned.

All four journals indicated that entries were made conscientiously for fourteen weeks during the semester. Students' accounts were rich with information, personal perceptions, and records of how time was spent. The journals revealed that each of the groups met at least once for every week of the semester, with some groups holding additional study meetings before tests. These journals kept by each group provided the data for analysis. The steps used for developing an organizing system for the unstructured qualitative data included the following: (1) getting a sense of the whole; (2) noting the topics, not the content; (3) listing the topics; (4) categorizing the topics to identify patterns; and (5) analyzing the content. A sense of the whole suggested that the task assignment entries of all four groups indicated that students defined their tasks in terms of completing homework problems and/or studying for a quiz or midterm. Several entries suggested, however, that students were not satisfied with this task definition.

Results

The first pattern, or perhaps non-pattern, to emerge from the entries relates to task definition. These entries reflect that the suggestions made on the instruction sheets to groups about information gathering activities largely were ignored, although two groups indicated that "something more" should probably be happening in their meetings:

> For the time invested in the group, we don't believe it was beneficial. All we worked on was homework problems. The group did not add to the understanding of physics....The cooperative study should be an enrichment of the class. But we didn't have a knowledge base from the class to build on. (G2, 4/26)

> We completed the homework and discussed how we feel about meeting. The general consensus seems to be that there might be good ideas somewhere in group learning, but it shouldn't be forced. Some of us don't feel like we're getting anything out of these meetings. We spend the whole time working on the homework problems and no time for what we are having problems with. We do have other classes. (G3, 4/3)

> We talked about what we think we should be getting out of these group meetings and decided it should be more than just homework. We do not have

> enough time to discuss any of our other problems we are experiencing in class. We want to set up tutoring sessions with E. [a graduate student mentor] if a time can be found convenient for all. (G3, 2/15)

A second pattern emerged from the journal entries: groups met to help each other succeed in the class. The desire to help others was expressed at first meetings of most groups. For instance, a long range goal expressed on the first day of meeting from one group was "to help one another get through Physics 350" (G3, 1/23) and from another group, a short range goal was "to get to know each other in order to help each other better" and "to work together to better understand what is taught in class or homework assignments." (G2, 1/22) References were made throughout the semester that indicated that helping one another continued to be a major goal of meeting together.

Throughout the semester, entries indicated positive attitudes about members of the group working together. Attitudes of this nature as well as concerns about members who were not attending meetings reflected a third pattern. Entries indicated overall satisfaction about group members' participation in meetings and performing particular tasks for the group. Comments like the following were common:

> Our group works very well together. We all put our heads together and try to approach the problems from the best solutions we can figure. We all try to help one another out. I believe the group is beneficial. (G5, 2/6)

> A couple of members were late, but when they finally arrived, our goals were accomplished. We seemed to get a lot done. We all worked together and a single person didn't try to take charge. It was a profitable meeting! (G5, 2/11)

> We work really well together and try to help each other out the best we can. (G1, 2/19)

> Once again, I believe we functioned well. Everyone worked together to get the problems done and to understand how they should be done. This group seems to understand and accept responsibility and no problems have arisen thus far. (G3, 2/2)

> We try to encourage, motivate, and help one another. (G2, 3/22)

A last entry to the journal of one group summarizes our perceptions that the social aspect of the cooperative learning groups far outweighed all other benefits perceived by these students:

> How this group functioned: Great. We are all friends from this and hopefully we will keep in touch. (G3, 4/24)

The fourth pattern was an early concern with grades. Goals expressed on the first meeting day included "to pass with a C" (G5 1/23), "to pass the class!!" (G2, 1/22), and "to pass class and pass quizzes." (G1, 1/29) This concern was also pervasive throughout the semester. Some comments, such as the following, indicate that groups made decisions and shared ideas about how to make a better grade, but few groups indicated any relationship between cooperative learning and the actual imporvement of grades.

> ...so we have talked about what the test is (possibly) going to be like, and how we should strive for a strong class average on the exam. (G2, 2/15)

> ...we decided it would be a good idea to review all past quizzes and homework assignments for our test, and even re-work all problems. (G2, 2/22)

> We each want to be able to do the problems on our own in order to pass the first test. (G3, 2/22)

> This was a group study meeting to prepare us for the test. Group members have been studying the chapters and old quiz problems to prepare prior to this meeting. There seems to be a general consensus [sic] of "STRESS" and inability to concentrate. (G5, 2/25)

> We discussed how some of us are getting better quiz grades, and feel a bit encouraged. Some are still highly disappointed. (G2, 3/29)

> We are all getting worried about the final. K. [the graduate student mentor] is going to help us as much as she can. She is going to make a review sheet for us. (G5, 4/10)

Of particular interest to us was a fifth pattern of entries indicating that students perceived that they are not capable of helping themselves learn physics. Students indicated a confusion and futility, albeit with a positive outlook, in their efforts: "We were all very confused about the homework, but we helped each other the best we could" (G1, 3/5), and earlier from the same group, ..."helped each other try to understand problems, but still not totally clear on how to do or set up the problem." (G1, 2/5) Another comment is similar: "Better group organization is needed, too. We felt that we were thrown out there with little explanation of how it [i.e., cooperative learning] is to work." (G2, 4/26).

The final pattern indicated that students did not perceive themselves as capable learners and that external help from "experts" was essential in achieving success. One group had a graduate student mentor who showed up infrequently for meetings. Entries were made each time that she did or did not meet with the group.

Group 5 relied heavily on K., their mentor, to help them with solving problems and often met at her house. It is interesting to note that this particular group, mentored by a nurturing female graduate student, had very strong positive feelings about its function early in the semester that continued until its last meeting.

> We all are starting to think a little "physic-ly." With K. pointing us in the right direction, we can figure it out. (G5, 2/13)

> Our group really seemed to function together. We kind of "take turns" helping one another. Instead of just one person doing the problems and then bringing them and letting everyone else copy, the person that has them done or understands "walks" the other members through the problems. I think that is what makes our group a success! (G5, 4/24)

Another group, mentored by E., another female graduate student in physics, also expressed dependency on their mentor. This group chose to meet in E.'s office. Their comments also indicate a close tie between positive perceptions of group functioning and trust in E.'s abilities.

> Once again this group seems to function well. The studying together helped a couple of us quite a bit. We feel very fortunate to have E. because she seems like she cares about us. This is evident by her willingness to help us. (G3, 2/22)

Rumors of another group, which was in fact mentored by a graduate student who was not well-prepared in physics and who practiced a more "hands-off" approach, were recorded as follows:

> We completed the assignment and then discussed how we heard from another group that they were just assigned "babysitters" who wouldn't help them. We decided this was stupid (if true). (G3, 4/17)

One other group was monitored by En., a male graduate student in physics. Early in the semester, En. was noted to be a "super guy." (G2, 2/25) "En. is a big help, but he really makes us think." (G2, 3/1) And a final comment, "We were lucky to have someone like En. who could explain Physics to us. It would be beneficial to have an actual group tutor. Hint!" (G2, 4/26)

Discussion

An analysis of the data in these journals indicates some general trends regarding the affective outcomes of implementing cooperative learning groups in the Physics 350 class. Groups were enjoyed as social experiences that provided students opportunities to work homework problems together, although several groups noted that "something else" was probably supposed to be happening that would enable them to learn more physics. Groups also provided opportunities for students to share worries about grades associated with homework, quizzes, and exams. They also shared ideas about how they might do better on the next assignment. On a positive note, then, cooperative learning groups provided a mechanism for communication, some problem solving, and group support. Unfortunately, however, the analysis also revealed no positive changes in the attitudes of students towards the study of physics or their own abilities to succeed in the course throughout the semester. Students relied on the expertise of their mentors and expressed dependency on them that may or may not have been real. The data pointed to pervasive, consistent feelings of dependency, helplessness, and anxiety about passing the course that were not alleviated by positive feelings regarding the members of the group and overall group functioning.

Conclusions

Although the cooperative learning groups resulted in very positive attitudes towards other members in the group and support for members in making plans to "do better" in the class, the cooperative learning groups as we set them up did not ameliorate attitudes towards the class as a whole or provide a structure that encouraged the development of independent learning practices and positive attitudes towards one's own abilities to be successful in physics. The external motivational factor of "making a good grade" drove group functioning, not an unusual finding at all in light of the present focus on evaluation as a determining force behind instructional and learning practices (Champagne, Lovitts, & Calinger, 1990).

The students, even in the small-group cooperative learning setting, demonstrated typical "maladaptive motivational behavior patterns" characterized by Dweck (1986). Maladaptive motivational behavior patterns are characteristic of both high and low ability children who demonstrate low confidence in their abilities and goal orientations towards gaining positive judgments and avoiding negative judgments of competence. . Dweck explains these patterns in terms of learners' underlying self-conceptualizations of a "theory" of intelligence as fixed rather than malleable. Dweck cites evidence of children with consistent maladaptive behaviors who, regardless of their ability, become impaired in their abilities to achieve and actually show decreases in their intellectual growth. Our findings in undergraduate non-science majors corroborate Dweck's studies with younger learners and may indicate the ultimate results of consistent maladaptive motivational patterns that began in childhood and become obvious in the university physics class.

For Further Study

These findings led to the development of an ameliorative intervention along social-cognitive lines for a third semester's pilot of the course that will incorporate issues of self-confidence, goal orientation, and adaptive motivational behaviors into the small-group cooperative learning structure of the course. Metacognitive strategies and ways to foster one's independence in learning will be explicitly described and reinforced by professors in class and graduate student mentors in small group meetings. Graduate student mentors will be trained as counselors to explicitly describe, discuss, and assist

students in correcting maladaptive motivational behaviors that may affect their learning of physics.

Notes

Group numbers and group dates of entries are noted after each entry in the results section of this paper. For example, (G2, 4/26) indicates that the entry came from the journal of group 2 on April 26.

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